M&S Project Description

• At the program level, obtain data concerning:
  - types of M&S in use
  - how M&S are applied
  - who develops, owns & maintains M&S
  - how M&S are certified for use
  - the extent of programs’ investment in M&S

• Data collected from 21 programs, Mar-Sept ‘99
  - Mixture of platforms, weapons, C4ISR
  - All Services
  - Contractor: Hicks & Associates, Inc.

Rationale: DOT&E is trying to find ways to make more use of M&S. Additional information was needed.
Project Motivation

- “T&E programs shall be structured to integrate all DT&E, OT&E, LFT&E and M&S...as an effective continuum” DoD 5000.2-R
- DoD acquisition policy and reform initiatives (e.g., simulation-based acquisition)
  - M&S is becoming “an integral part of T&E planning, learning and understanding the system life-cycle”
- Prominent joint themes (e.g., Interoperability, System of Systems) require balance between M&S and T&E
- DOT&E responsibilities require insight into/confidence in M&S
- Data needed to inform policy decisions on relationship of M&S to T&E

Increasing dependence on M&S means programs must plan for M&S development, use and management
Actions Taken / Planned

• Briefed study results to:
  - DDR&E (2/23); DUSD(S&T)(12/27); DMSO (2/23)
  - SAEs (USAF 1/11, Army 1/18, Navy 1/20)
  - Participating Program Managers (2/24)
  - Industrial Committee on OT&E (2/28)

• Establishing pilot programs with SAEs to examine how M&S could be better used to support T&E

• Will more thoroughly address M&S plans in program reviews, TEMPs and Test Plans

• Will work with DUSD(S&T) to
  - Further develop M&S for operational test design
    • Potential use of HPC network
  - Improve migration of M&S applications from S&T to program offices
Initial Approach

H&AI Principal/Consultant
- Mike Donley
- George Singley
- Cliff Duncan
- Robert Gormley
- John Kramar

SAE Offices
- Navy: Mr. Buchanan, ASN(RDA)
- Army: LTG Kern, Mil Dep to ASA(RDA)
- Air Force: Mr. Durante, DASAF (Mgmt Policy & Program Integration)

PEOs
- Navy: RADM Newsome (Air ASW, Assault & Special Mission Programs)
- Army: RADM Strong (Cruise Missiles & Joint UAVs)
- Air Force: RADM Sargent (Expeditionary Warfare)
- Navy: Mr. Eaton (Space, Communications & Sensors)
- Army: RADM Davis (Submarines)
- Air Force: RADM Cook (Tactical Aircraft Programs)

PMs
- H&AI briefings/interviews/follow-up

“OK to Respond”

21 of 23 programs completed survey

Navy
- RADM Newsome (Air ASW, Assault & Special Mission Programs)
- RADM Strong (Cruise Missiles & Joint UAVs)
- RADM Sargent (Expeditionary Warfare)
- Mr. Eaton (Space, Communications & Sensors)
- RADM Davis (Submarines)
- RADM Cook (Tactical Aircraft Programs)

Army
- MG Snider (Aviation)
- MG Michitsch (Ground Combat & Support Systems)
- COL Holly (Tactical Missiles)

Air Force
- MG Bolton (Fighters & Bombers)
- Mr. Collins (Space)
- Mr. Diamond (Weapons)
Approach: Survey Content

<table>
<thead>
<tr>
<th>MODELS &amp; SIMULATIONS</th>
<th>Definitions of M&amp;S types from DMSO SBA Roadmap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>M&amp;S “asset category”</td>
</tr>
<tr>
<td>Name/Description/Owner</td>
<td>Survey questions</td>
</tr>
<tr>
<td>VV&amp;A Status, Source</td>
<td>Types of Models and Simulations</td>
</tr>
<tr>
<td>Activities Supported (Phase and Type)</td>
<td>Types of Models and Simulations</td>
</tr>
<tr>
<td>Level/Source/Custodian of Funding</td>
<td>Types of Models and Simulations</td>
</tr>
<tr>
<td>Man-Hours Spent</td>
<td>Types of Models and Simulations</td>
</tr>
<tr>
<td>Overall Utility</td>
<td>Types of Models and Simulations</td>
</tr>
</tbody>
</table>

**Environmental**
- Authoritative Representations of the Environment

**Combat**
- Constructive Mission Models
- Constructive Campaign & Theater Models
- Constructive Engagement Models
- Virtual Prototypes
- HWIL Test Tools
- Constructive Threat Models
- Man-in-the-Loop Test Tools
- Live Simulations

**Logistics**
- Constructive Logistics Models
- Constructive Availability Models
- Constructive Maintainability Models
- Constructive Reliability Models
- Constructive Supportability Models

**Engineering/Design/Manufacturing**
- Virtual 3-D Layout/Mockup of the System with a Behavioral Capability
- Virtual Manufacturing Plant Simulations
- Constructive Engineering Models
- Constructive Manufacturing Models

**Training**
- Onboard Training Systems
- Virtual Crew Simulators
Summary of Survey Respondents to Date

<table>
<thead>
<tr>
<th>Program</th>
<th>Component</th>
<th>System Type</th>
<th>Current Status*</th>
<th>FRP Date*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crusader</td>
<td>Army</td>
<td>Platform</td>
<td>MSII decision 2001</td>
<td>1QFY06</td>
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<tr>
<td>Comanche</td>
<td>Army</td>
<td>Platform</td>
<td>MSII decision FY02</td>
<td>1QFY07</td>
</tr>
<tr>
<td>M1A2 Upgrade</td>
<td>Army</td>
<td>Platform</td>
<td>FRP</td>
<td>3QFY94</td>
</tr>
<tr>
<td>ATACMS Blk II/BAT</td>
<td>Army</td>
<td>Weapon</td>
<td>LRIP</td>
<td>3QFY00</td>
</tr>
<tr>
<td>Javelin</td>
<td>Army</td>
<td>Weapon</td>
<td>FRP</td>
<td>3QFY97</td>
</tr>
<tr>
<td>SADARM</td>
<td>Army</td>
<td>Weapon</td>
<td>LRIP</td>
<td>4QFY98</td>
</tr>
<tr>
<td>FAAD C2</td>
<td>Army</td>
<td>C4ISR</td>
<td>FRP</td>
<td>3QFY95</td>
</tr>
<tr>
<td>C2 Vehicle</td>
<td>Army</td>
<td>C4ISR</td>
<td>LRIP</td>
<td>1QFY00</td>
</tr>
<tr>
<td>F/A-18 E/F</td>
<td>Navy</td>
<td>Platform</td>
<td>LRIP</td>
<td>3QFY00</td>
</tr>
<tr>
<td>V-22 Osprey</td>
<td>Navy/USMC</td>
<td>Platform</td>
<td>LRIP</td>
<td>2QFY00</td>
</tr>
<tr>
<td>LPD-17</td>
<td>Navy/USMC</td>
<td>Platform</td>
<td>EMD</td>
<td>3QFY07</td>
</tr>
<tr>
<td>AIM-9X</td>
<td>Navy</td>
<td>Weapon</td>
<td>LRIP</td>
<td>1QFY02</td>
</tr>
<tr>
<td>AN/BSY-2 (SSN-21)</td>
<td>Navy</td>
<td>C4ISR</td>
<td>Sea Trials on SSN-22 (USS CONNECTICUT)</td>
<td>N/A</td>
</tr>
<tr>
<td>UHF Follow-On</td>
<td>Navy</td>
<td>C4ISR</td>
<td>Completing FRP</td>
<td>4QFY88</td>
</tr>
<tr>
<td>SLAM-ER</td>
<td>Navy</td>
<td>Weapon</td>
<td>FRP</td>
<td>2QFY99</td>
</tr>
<tr>
<td>F-22</td>
<td>USAF</td>
<td>Platform</td>
<td>LRIP</td>
<td>3QFY03</td>
</tr>
<tr>
<td>B-2</td>
<td>USAF</td>
<td>Platform</td>
<td>IOC</td>
<td>N/A (did not enter FRP)</td>
</tr>
<tr>
<td>EELV</td>
<td>USAF</td>
<td>Platform</td>
<td>MSII Decision FY99</td>
<td>2QFY03 (MSIII decision 1QFY03)</td>
</tr>
<tr>
<td>ABL</td>
<td>USAF</td>
<td>Weapon</td>
<td>MSII decision FY03</td>
<td>2QFY05</td>
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<tr>
<td>SBIRS</td>
<td>USAF</td>
<td>C4ISR</td>
<td>MSII decision 1996</td>
<td>First GEO sat deliv. FY02; HEO FY03; LEO FY-04</td>
</tr>
<tr>
<td>SFW P3I</td>
<td>USAF</td>
<td>Weapon</td>
<td>FRP</td>
<td>3QFY96</td>
</tr>
</tbody>
</table>

*Source: DOT&E FY98 Annual Report to Congress
M&S Characterization
By Program Type

- Types of M&S used driven partly by program type
- "Platform" programs utilized more total M&S assets and comparatively higher percentage of logistics and combat M&S types
- "C4ISR" programs utilized comparatively higher percentage of training M&S

<table>
<thead>
<tr>
<th>Program Type</th>
<th># programs</th>
<th>% of M&amp;S</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4ISR</td>
<td>5</td>
<td>17%</td>
</tr>
<tr>
<td>Weapon</td>
<td>7</td>
<td>33%</td>
</tr>
<tr>
<td>Platform</td>
<td>7</td>
<td>50%</td>
</tr>
</tbody>
</table>

359 Total M&S

Major M&S Categories

- Environment
- Combat
- Logistics
- Engineering, Design/Manuf.
- Training

[Bar chart showing distribution by program type for C4ISR, Weapon, and Platform]
M&S Characterization
Common M&S

- **Combat Models**
  - ALARM (2)
  - ASAP (2)
  - CASTFOREM (2)
  - SUPPRESSOR (4)
  - TRAP (3)

- **Engineering/Design/Manufacturing**
  - ANSYS (2)
  - APART (2)
  - CATIA (3)
  - COVART (3)
  - DYNA 2D (2)
  - ESAMS (3)
  - FASTGEN (3)
  - JSEM (2)
  - Pro-E (5)

- **Logistics**
  - COMPASS (2)
  - LCOM (2)
  - RELEX (3)
  - TIGER (2)

- **Environments**
  - EOSAEL (2)
  - LOWTRAN (5)
  - MODTRAN (2)
  - NASTRAN (5)
  - PATRAN (5)
  - SINDA (3)

**Exploiting M&S commonality:**

- Best-of-breed?
- Strengths/Weaknesses?
- Limits on extension/application?
- VV&A status?
**M&S Management**

**Requirements for SBA, Acquisition Reform**

**Acquisition Reform**

“Better, faster, cheaper material solutions”

- DoD 5000.1
- DoD 5000.2-R

**Simulation-Based Acquisition:**

- Balance Requirements
- Explore Design Alternatives
- Establish Iterative Design Process
- Test as Integral Part of Design Process
- Conduct Decision Risk Analysis

**Selected M&S Management Activities Deemed Critical to SBA Success:**

- M&S Support Plan
- MS&A staff including users
- VV&A plan/process
- M&S re-use (incl. COTS)
- Collaborative environment
- Incentivized performance
Incorporation of Selected M&S Management Activities

- Services vary in their approach to M&S management
- Approach also varies by program maturity
M&S Management

Developers

- 219 M&S from 13 programs
- Crusader, F/A-18E/F, Javelin, FAADC2, AIM-9X, ATACMS/BAT and Comanche did not provide data on M&S developers

Owners

- 359 M&S

- Industry is the predominant developer/owner
- Extent of industry involvement in Service/Government-developed M&S (30%) unknown
VV&A Overview

Who Does VV&A?

- Uncertainty about “pedigree” of M&S being used (35%)
- Potential conflicts of interest (25%)
- VV&A standards for COTS M&S?
- Use of joint/independent processes low (7%)
M&S Cost Overview

- M&S development and application costs data are not readily available within acquisition programs
# M&S Cost Summary

<table>
<thead>
<tr>
<th>Program</th>
<th>Approx. Acquisition Cost</th>
<th>M&amp;S Development Expenditures to Date</th>
<th>Reported M&amp;S exp. to date as % of Total Acquisition Cost</th>
<th>% of M&amp;S with Cost Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPD-17</td>
<td>$10B</td>
<td>$38M</td>
<td>&lt;1%</td>
<td>100%</td>
</tr>
<tr>
<td>ATACMS/BAT</td>
<td>$5B</td>
<td>$25.2M</td>
<td>&lt;1%</td>
<td>100%</td>
</tr>
<tr>
<td>Javelin</td>
<td>$4B</td>
<td>$48M</td>
<td>1.2%</td>
<td>100%</td>
</tr>
<tr>
<td>AN/BSY-2</td>
<td>$3B</td>
<td>$58.3M</td>
<td>1.9%</td>
<td>100%</td>
</tr>
<tr>
<td>SADARM</td>
<td>$3B</td>
<td>$14.6M</td>
<td>&lt;1%</td>
<td>78%</td>
</tr>
<tr>
<td>V-22</td>
<td>$37B</td>
<td>$50.2M</td>
<td>&lt;1%</td>
<td>44%</td>
</tr>
<tr>
<td>FAAD C2</td>
<td>$1B</td>
<td>$37.6M</td>
<td>3.7%</td>
<td>40%</td>
</tr>
<tr>
<td>SLAM-ER</td>
<td>$.5B</td>
<td>$8.1M</td>
<td>1.6%</td>
<td>21%</td>
</tr>
<tr>
<td>F/A-18E/F</td>
<td>$46B</td>
<td>$15.1M</td>
<td>&lt;1%</td>
<td>5%</td>
</tr>
<tr>
<td>SBIRS</td>
<td>$8B</td>
<td>$28M</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

## M&S as Percentage of RDT&E: The ATACMS/BAT Example

<table>
<thead>
<tr>
<th>RDT&amp;E Expenditures to Date*</th>
<th>M&amp;S Investment to Date*</th>
<th>M&amp;S Investment as % of RDT&amp;E Expenditures to Date*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.46B</td>
<td>$25.2M</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

* Through FY99
Observations

• Programs must invest early in M&S if M&S is to make a difference in acquisition
• PMs do not view DoD-wide M&S investments as cost or schedule effective
• Additional effort is required for M&S to support acquisition
  - Increase use of M&S in program planning/design, execution, data analysis and archiving
• Quality of M&S support to Program Offices needs review
  - M&S suitability/credibility may be unknown or assumed
• Future M&S requirements need to be identified
  - Program Offices are “here and now” oriented
• Need improved understanding of M&S management activities necessary for SBA success
• Building a business case for M&S is difficult
  - Unavailability of cost data and return on investment
• Industry plays a predominant role in M&S development and ownership
  - source of expertise and substantial funding
  - impact of proprietary restrictions needs to be examined
Recommendations for USD (A,T&L)

• Direct the implementation of a process to identify and satisfy M&S requirements for joint, coalition and system of systems development

• Emphasize the important role that acquisition programs must play in the development of M&S
  - incentivize Program Office investment in M&S
  - address M&S in the 5000 series
  - have PEOs/PMs coordinate program plans, M&S assumptions, and performance predictions prior to testing

• Review and clarify roles and functions of DoD M&S organizations
  - “who’s doing what” and “who should be doing what”
  - gaps/overlaps
  - identify necessary revisions/additions to OPRs
    • e.g., assign responsibility for tracking total DoD M&S investment
  - identify and coordinate M&S priorities and funding source
Recommendations for USD (A,T&L)

• Foster an improved understanding of the interrelationship of T&E and M&S
  - Endorse pilot programs with the SAEs that examine and demonstrate the utility of M&S for T&E
    • add to list of issues for weekly luncheon meeting
      - background information to be provided by DOT&E

• Examine payoff from M&S in life cycle cost
• Establish a forum to address industry strengths and challenges